

Claims

1. A method of machining a silicon body (W) of a silicon wafer substrate with an ultraviolet or green visible wavelength laser beam (6), comprising the steps of:
 - a. providing an environment of a liquid halide compound or refrigerated liquid tetrafluoroethane or a liquid comprising a mixture of halocarbons and other liquids in at least a machining location of the silicon body;
 - b. directing the laser beam at the machining location of the silicon body in the environment of the liquid halide compound or refrigerated liquid tetrafluoroethane or a liquid comprising a mixture of halocarbons and other liquids;
 - c. locally heating the liquid halide compound or refrigerated liquid tetrafluoroethane or the liquid comprising a mixture of halocarbons and other liquids with the laser beam in the vicinity of the machining location of the silicon body sufficiently to cause a chemical reaction between the silicon body and the liquid halide compound or refrigerated liquid tetrafluoroethane or the liquid comprising a mixture of halocarbons and other liquids at the machining location;
 - d. machining the silicon body at the machining location with the laser beam, thereby causing the chemical reaction to take place at the machining location to form at least one of gaseous and solid by-products; and
 - e. venting any gaseous by-products from the environment of the liquid halide compound or refrigerated liquid tetrafluoroethane or the liquid comprising a mixture of halocarbons and other liquids and dispersing any solid by-products in the liquid halide compound or refrigerated liquid tetrafluoroethane or the liquid comprising a mixture of halocarbons and other liquids.
2. A method as claimed in claim 1, wherein the step of providing the environment of a liquid halide compound or refrigerated liquid tetrafluoroethane or a liquid comprising a mixture of halocarbons and other liquids comprises providing an environmental chamber (2) for containing the

liquid halide compound or refrigerated liquid tetrafluoroethane or a liquid comprising a mixture of halocarbons and other liquids.

3. A method as claimed in claims 1 or 2, wherein the step of providing the environment of a liquid halide compound or refrigerated liquid tetrafluoroethane or a liquid comprising a mixture of halocarbons and other liquids comprises providing a refrigerated liquid halide compound or a refrigerated liquid comprising a mixture of halocarbons and other liquids.
4. A method as claimed in claim 3, wherein the step of providing the refrigerated liquid halide compound or the refrigerated liquid comprising a mixture of halocarbons and other liquids comprises controlling a temperature of the refrigerated liquid halide compound or the refrigerated liquid comprising a mixture of halocarbons and other liquids before, during and after machining.
5. A method as claimed in any of the preceding claims, wherein the step of providing the environment of a liquid halide compound or refrigerated liquid tetrafluoroethane or a liquid comprising a mixture of halocarbons and other liquids comprises providing aerosol nozzle means for delivering the liquid halide compound or refrigerated liquid tetrafluoroethane or the liquid comprising a mixture of halocarbons and other liquids to at least the machining location.
6. A method as claimed in any of the preceding claims, wherein the step of providing the environment of a liquid halide compound or refrigerated liquid tetrafluoroethane or a liquid comprising a mixture of halocarbons and other liquids comprises providing a halocarbon containing a halogen selected from the group of fluorine, chlorine, bromine and iodine.
7. A method as claimed in any of the preceding claims, wherein the step of machining the silicon body comprises controlling a temperature of the silicon body substantially to prevent thermal damage to the silicon body by controlling thermal loading of the silicon body.
8. A method as claimed in any of the preceding claims, wherein the step of machining the silicon body comprises machining at least one of a via structure, a dice lane and a scribe lane in the silicon body.

9. A method as claimed in any of the preceding claims, wherein machining a silicon body comprises machining a body containing a significant proportion of silicon.
10. A method as claimed in claim 9, wherein the step of machining a body containing a significant proportion of silicon comprises machining a multilayer structure.
11. A method as claimed in claim 10, wherein machining a multilayer structure comprises machining a multilayer structure having a plurality of layers of semiconductor, metal, interlayer dielectric and ceramic materials.
12. A laser machining apparatus (1) for machining a silicon body of a silicon wafer substrate comprising: an ultraviolet or green visible wavelength laser; means (2) for providing a controlled environment of a liquid halide compound or refrigerated liquid tetrafluoroethane or a liquid comprising a mixture of halocarbons and other liquids in at least a machining location of the silicon body; means (10) for directing a laser beam (6) from the laser onto the machining location locally to heat the liquid halide compound or refrigerated liquid tetrafluoroethane or the liquid comprising a mixture of halocarbons and other liquids with the laser beam in the vicinity of the machining location of the silicon body sufficiently to cause a chemical reaction between the silicon body and the liquid halide compound or refrigerated liquid tetrafluoroethane or the liquid comprising a mixture of halocarbons and other liquids at the machining location and to machine the silicon body at the machining location with the laser beam, thereby causing the chemical reaction to take place at the machining location to form at least one of gaseous and solid by-products such that any solid by-products are dispersed in the liquid halide compound or refrigerated liquid tetrafluoroethane or the liquid comprising a mixture of halocarbons and other liquids; and venting means (5) arranged to vent any gaseous by-products from the environment of the liquid halide compound or refrigerated liquid tetrafluoroethane or the liquid comprising a mixture of halocarbons and other liquids.
13. A laser machining apparatus as claimed in claim 12, wherein the means for providing the controlled environment of a liquid halide compound or

refrigerated liquid tetrafluoroethane or a liquid comprising a mixture of halocarbons and other liquids is arranged to provide a controlled liquid halocarbon environment.

14. A laser machining apparatus as claimed in claims 12 or 13, wherein the means for providing the controlled environment of a liquid halide compound or refrigerated liquid tetrafluoroethane or a liquid comprising a mixture of halocarbons and other liquids comprises environmental chamber means.
15. A laser machining apparatus as claimed in claim 14, wherein the environmental chamber means comprises bath means for a refrigerated liquid halide compound.
16. A laser machining apparatus as claimed in claims 14 or 15, wherein the environmental chamber means comprises an inlet port (3) and an outlet port (4) for the liquid halide compound, and a gas vent (5).
17. A laser machining apparatus as claimed in any of claims 14 to 16, wherein the environmental chamber means comprises a window (15) transparent to the laser beam for entry of the laser beam (6) into the environmental chamber means.
18. A laser machining apparatus as claimed in claim 17, wherein the window is anti-reflection coated.
19. A laser machining apparatus as claimed in any of claims 14 to 18, comprising refrigeration means for providing a refrigerated liquid halide compound or a liquid comprising a mixtures of halocarbons and other liquids to the environmental chamber means.
20. A laser machining apparatus as claimed in claim 19, wherein the refrigeration means is arranged for controlling a temperature of the liquid halide compound or the liquid comprising a mixtures of halocarbons and other liquids before, during and after machining.
21. A laser machining apparatus as claimed in any of claims 12 to 20, wherein the means for providing the environment of a liquid halide compound or refrigerated liquid tetrafluoroethane or a liquid comprising a mixture of halocarbons and other liquids comprises aerosol nozzle means for delivering

the liquid halide compound or refrigerated liquid tetrafluoroethane or a liquid comprising a mixture of halocarbons and other liquids at least to the machining location.

22. A laser machining apparatus as claimed in any of claims 12 to 21 comprising temperature control means for controlling a temperature of the silicon body (W) to be machined at the machining location, arranged substantially to prevent thermal damage of the body by controlling thermal loading of the silicon body.
23. A laser machining apparatus as claimed in claim 19, further comprising telecentric lens means for directing the laser beam, wherein a flow of the refrigerated liquid halide compound substantially fills a field of view of the telecentric lens means.

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